THE EFFECTS OF CROSSCUTTING BEFORE GANG-RIPPING ON DIMENSION PART YIELDS FROM No.1 AND 2A COMMON RED OAK LUMBER

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ABSTRACT

Mills should have the option to crosscut red oak lumber prior to gang-ripping to remove crook and worthless material and to take advantage of the quality differences between board ends. At least half of No: 1 and 2A Common red oak boards will have end-to-end yield differences of at least 10 percent. Preprocessing will cause a slight decrease in overall yield but will allow greater control of the material fed to the gang ripsaw. It also appears that fewer short lengths will be generated from the better sections of the boards.

In earlier work, [1] we found that hardwood lumber usually has a better and a worse end. Further, more than half of all No.1 Common and No. 2A Common boards will yield 10 percent more clear cuttings from one end than the other. The better ends will produce more overall yield, more primary yield, less salvage yield, and more yield in longer and wider cuttings.

In the future, when vision systems and automated processing allow us to obtain maximum yields from every board, the effects of the better and worse ends will be taken care of automatically. But what of to day's gang-rip-first rough mill? Is the recommendation to have a crosscut saw ahead of the gang ripsaw reasonable? From our earlier work on boards with crook or side bend,[2,3] the answer was yes. But there may be other reasons to crosscut boards before gangripping. In this work, we focus only on straight boards with 10 percent (or more) end-to-end yield differences and examine three ways to crosscut these boards before gang-ripping.

THE STUDY

Yields from gang-ripping are cutting-bill specific. That is, they will vary depending on such variables as arbor setup, specified part lengths and widths, how the chop saw optimizes yield between two defects, and lumber grade. When there is a wide range of part lengths and the gang-ripped strips are narrow, much of the yield will be in long-length cuttings that are simply crosscut from fullwidth strips (primary cuttings). This is particularly true when yields are based on placing the longest possible part length between two defects. We refer to this as the I-length method of chop saw optimization. When as many as three lengths are placed between defects in order to get the highest yield (3-length method), the total yield goes up slightly but the amount in the longest lengths is decreased.

In our previous study 1, we examined 465 No.1 Common and 537 No.2A Common boards that were 8 feet long or longer. We used 1.5*1.25 and 3.0*2.0 arbor setups. The 1.5*1.25 means that a 1.5-inch strip width is repeated until the outer edge of the board is approached. If the remainder is at least 1.25 inches, processing continues. If less than 1.25 inches, the last 1.5-inch strip is skipped and the blade is floated out to the board edge. For this arbor, strip widths range from 1.25 to 2.75 inches. Part length yield estimates were obtained with the I-length and 3-length chop saw optimization methods. Part lengths were 15, 18, 25,29,33,38,45,50,60, and 72 inches.

1 Gatchell, c.J., J.K. Wiedenbeck, and E.S. Walker. 1995. Understanding that red oak lumber has a better and a worse end. Forest Prod. 1. 45(4): 54-60.

2 Gatchell, C.J. 1990. The effect of crook on yield when processing narrow lumber with a fixed arbor gang ripsaw. Forest Prod. J. 40(5): 9-17.

3 Gatchell, C.J. 1991. Yield comparisons from floating blade and fixed arbor gang ripsaws when processing boards before and after crook removal. Forest Prod. 1. 41(5):9-17.

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TABLE 1. - Distribution of surface areas of lumber pieces from three crosscut-based preprocessing methods.

Grade	Crosscut method	1-length[a] (244 boards) Better	Worse	Hogged	3-length[b] (254 boards) Better	Worse	Hogged
		(% of sample)					
No. 1 Common	50/50[c]	50.0	50.0	0.0	50.0	50.0	0.0
	Restricted[d]	73.3	23.9	2.8	72.3	25.3	2.4
	Unrestricted[e]	83.7	12.8	3.5	83.0	13.7	3.3
		1-length (302 boards)			3-length (312 boards)		
		(% of sample)					
No. 2A Common	50/50	50.0	50.0	0.0	50.0	50.0	0.0
	Restricted	63.3	31.1	5.6	62.9	31.6	5.5
	Unrestricted	72.4	22.9	4.7	72.8	22.4	4.8

[a] 1-length = longest possible length between two defects always taken first.
[b] 3-length = use the three lengths that give the greatest yield in primary parts from between two defects.
[c] Full-length boards crosscut in half.
[d] Length of shortest piece should be at least 1/4 of full length. Specified minimum = 34 inches that can be overridden.
[e] Crosscut at any point along board length.

The number of No. 1 Common boards with 10 percent or more primary yield differences between board halves varied from 244 (I-length, 1.5* 1.25) to 325 (3-length, 3.0*2.0). For No. 2A Common, the range was 302 boards (1-length, 1.5*1.25) to 383 boards (3-length, 3.0*2.0). Thus, more than 50 percent of all No.1 and 2A Common boards in our earlier study had at least a 10 percent end-to-end yield difference when long, narrow parts were sought (1.5 to 2.75 in. wide) on the 1.5*1.25 arbor. This increased to 70 percent when short, wide pieces were produced (3.0 to 5.0 in. wide on the 3.0*2.0 arbor).

The 3.0*2.0 arbor setup was judged to be impractical for No. 2A Common gang-ripping because there are not large amounts of 3.0- to 5.0-inch-wide cuttings in long lengths and much salvage work is required to get acceptable total yields. Therefore, we focus here only on the 1.5*1.25 arbor. All other variables and procedures from the earlier study were used including the I-and 3-length methods of obtaining parts. The I-length and 3-length chop saw optimization methods produce significantly different part length distributions. We investigate two new ways to crosscut boards prior to gang-ripping and compare these to simply cutting the boards in half. The latter results were brought forward from our previous study.

PROCESSING PROCEDURE

In this study, the terms 'better' and 'worse' take on new meaning. In the earlier work, where boards were simply cut in half and then gang-ripped, better and worse were based on actual yields. In this study, better and worse are based on predictions of the types and amounts of yields that will result from various choices of where to crosscut before gangripping and are, therefore, somewhat subjective. In this study, a better piece is one whose projected yields are estimated to be primary and where little salvaging effort is required. It is quite possible that a better piece(s) from a board will be shorter than a worse piece(s).

The data sets were crosscut before gang-ripping using a computer program developed by Walker and Gatchell.[4] Any board can be crosscut into as many as six pieces and each piece can be sorted into a separate classification. We used three classifications: better, worse, and hogged. The last classification includes kerf. In this study, we examine two new crosscut-first procedures that differ by whether a minimum length is specified for any piece that is to be gang-ripped. In the restricted crosscutting method, a minimum length for all but the hogged pieces is specified. In the unrestricted crosscutting method, no minimum piece length is specified.

The restricted crosscutting method was designed to simulate procedures for removing crook that were developed earlier.2,3 While we used straight boards in this study, each board must be crosscut at least once to simulate removal of crook. The shortest board section for gang-ripping was arbitrarily specified at 34 inches. This allowed for the 33-inch specified cutting bill length plus a I-inch end trim allowance.

For unrestricted crosscutting, the operator can crosscut at any point along the board length or choose not to crosscut at all. The operator is free to pass the full-length board on to the better or the worse sort.

For both restricted and unrestricted crosscutting, it is possible to hog sections from which no yield can be obtained. Thus, long boards can be cut to several sections and once the sections to be hogged are removed, all sections to be gang-ripped can be placed in the better or worse sort, or a combination of better and worse sorts.

Yields from any given board will depend on the cutting bill, the arbor set up (only one arbor is included in this study), the way strips are chopped to parts (longest length between defects or three longest lengths between defects), and the method and location of crosscutting. Some boards will have 10 percent or more end-to-end yield differences under some circumstances and not others. That is why the number of boards in the samples are not the same. Boards common to two or more samples were preprocessed (crosscut) the same for each sample.

RESULTS

The yield results from the full-length boards and from the better and worse ends of boards that were crosscut in half (the 50/50 boards in this study) were those from the earlier study. [1] In that work, yields could be compared directly on a percentage basis because the surface area of the better and worse samples was the same. In this study, the amount of material in the better and worse categories will vary and some sections will be hogged. Therefore, all yields are given as a percentage of the surface area of 1,000 board feet (MBF) of lumber.

Our discussion will start with a summary of how much of the input lumber was placed in the better, worse, and hogged categories. Then, an overview of the combined yields from the better and worse ends and from the full-length boards will be followed by a more detailed look at the yields from the re

[4] Walker, E.S. and C.J. Gatchell. 199_. Rem Chop: a computer program for preliminary remanufacturing oflumber by crosscutting. Res. Pap., USDA Forest Serv., NE Forest Expt. S1o., Radnor, Pa. (in process).

TABLE 2. - *A comparison of yields from the better and worse pieces of lumber preprocessed by crosscutting in a gang-rip-first roughmill and yields from full-length, not preprocessed boards.*

Grade	Primary length	Crosscut method — 1-length[a]				Crosscut method — 3-length[b]			
		None (full[c] length)	Unrestriced[d]	Restricted[e]	50/50[f]	None (full length)	Unrestricted	Restricted	50/50
	(in.)	(% of lumber input)							
No. 1 Common	72	32.9	29.4	20.4	16.8	10.1	8.4	5.8	7.0
	50, 60	13.9	15.3	21.1	20.6	18.7	15.6	12.1	14.3
	38, 45	8.4	8.5	9.4	14.2	10.7	11.7	11.7	7.7
	25, 29, 33	7.5	8.1	9.9	8.3	18.3	20.0	24.0	22.8
	15, 18	4.3	4.3	4.2	5.2	12.2	12.9	14.9	16.3
	Primary total	67.0	65.6	65.0	65.1	70.0	68.6	68.5	68.1
	Salvage	3.8	3.5	3.6	3.8	3.4	3.2	3.3	3.7
	Total	70.8	69.1	68.6	68.9	73.4	71.8	71.8	71.8
No. 2A Common	72	18.7	15.4	10.4	6.5	4.0	3.6	1.7	2.8
	50, 60	15.1	16.6	18.0	15.2	11.5	9.9	8.2	8.0
	38, 45	9.9	9.5	11.3	16.2	11.4	11.3	11.1	8.2
	25, 29, 33	9.7	10.6	11.8	12.0	19.9	20.2	21.7	22.0
	15, 18	6.3	6.4	6.4	7.7	15.6	16.2	17.8	18.8
	Primary total	59.7	58.5	57.9	57.6	62.4	61.2	60.5	59.8
	Salvage	4.5	4.0	3.9	4.5	4.0	3.7	3.7	4.4
	Total	64.2	62.5	61.8	62.1	66.4	64.9	64.2	64.2

[a] 1-length = longest possible part length between two defects always taken first.
[b] 3-length = use the three lengths that give the greatest yield in primary parts from between two defects.
[c] None = full-length boards.
[d] Unrestricted = crosscut at any point along board length.
[e] Restricted = length of shortest piece should be at least 1/4 of full length. Specified minimum = 34 inches that can be overridden.
[f] 50/50 = full-length boards crosscut in half.

stricted and unrestricted crosscutting procedures. We will conclude with a discussion of the potential benefits of having a crosscut saw ahead of the gang ripsaw.

The amount of material in the better and worse pieces from the three crosscut-first methods (cut in half (50/50), restricted, and unrestricted) is shown in Table 1. The data sets for the I-length and 3-length methods were made up mostly of the same boards. Because we did not change our crosscutting positions for boards common to both data sets, there was not much difference in the amounts of material in the better and worse piece categories for the I-length and 3-length methods. The No.1 Common lumber produced about 10 percent more material in the better category than did the No. 2A Common.

The unrestricted crosscutting method (no minimum length specified) produced about 10 percent more material in the better classification than did the restricted method. The minimum length specified in the restricted crosscutting part of the study was 34 inches. Occasionally, the worse section would be far shorter than this. One result of this is that the worse piece must then contain some better material. This, in turn, reduces the amount of material in the better category. Table 1 shows the results of our crosscutting decisions. All percentages for each set of variables add to 100.

The total (better + worse) yields from the better and worse pieces for the three crosscut-first methods are compared with the total yields from the full-length boards in Table 2. There was slightly more yield from the 3-length gang-rip than from the I-length method. With these methods, there was slightly less yield from the remanufactured boards than from the full-length boards. It is interesting to note that any of the crosscutting methods that are followed by the 3-length strip processing method have greater total yields than full-length boards when processed with the I-length method. Having said that, there is no important negative effect of preprocessing before gang-ripping on total yields or on the primary and salvage totals. Further, crosscutting out areas that are mostly defective (hogged and kerf) does not affect total yields. This can be seen by comparing yields for the 50/50 crosscutting method, in which no sections were hogged, and the other two crosscutting methods (Table 2).

The important effects of preprocessing by crosscutting are found in Table 2, which shows combined part yields for all board sections. Cutting boards in half is the least effective way to produce long lengths. Unrestricted crosscutting to remove waste (hogged material) and separate the better from the worse pieces is the most effective method and produces total yield length distributions similar to full-length boards. Restricted crosscutting, as might be done to remove crook, gives excellent yields in all but the longest lengths. Recall that the true benefits of unrestricted crosscutting for crook removal are not captured here, as this study only addresses straight boards. As was found in our earlier work, preprocessing does not greatly increase the amount of short-length material.

Length distributions for the better and worse pieces from the restricted and unrestricted crosscutting procedures are shown in Table 3. The 1- and 3-length yield patterns followed those of the earlier study with the 3-length pattern producing slightly more yield and more yield in the shorter

TABLE 3. — The effects of unrestricted[a] and restricted[b] crosscutting before gang-ripping on the area-based yields from the better and worse ends of red oak boards.

		Unrestricted crosscut						Restricted crosscut					
		1-length (244 boards)[c]			3-length (254 boards)[d]			1-length (244 boards)			3-length (254 boards)		
Grade	Part length	Better (83.7% of input)	Worse (12.8% of input)	Total	Better (83.0% of input)	Worse (13.7% of input)	Total	Better (73.3% of input)	Worse (23.9% of input)	Total	Better (72.3% of input)	Worse (25.3% of input)	Total
	(in.)	(% of lumber input)											
No. 1 Common	72	29.1	0.3	29.4	8.3	0.1	8.4	19.4	1.0	20.4	5.4	0.4	5.8
	50,60	13.4	1.9	15.3	15.3	3.3	15.6	18.1	3.0	21.1	11.3	0.8	12.1
	38,45	7.3	1.2	8.5	10.6	1.1	11.7	6.7	2.7	9.4	9.6	2.1	11.7
	25,29,33	5.9	2.2	8.1	16.6	3.4	20.0	5.6	4.3	9.9	18.0	6.0	24.0
	15,18	3.2	1.1	4.3	10.2	2.7	12.9	2.3	1.9	4.2	10.1	4.8	14.9
	Primary total	58.9	6.7	65.6	61.0	10.6	68.6	52.1	12.9	65.0	54.4	14.1	68.5
	Salvage	2.7	0.8	3.5	2.5	0.7	3.2	2.2	1.4	3.6	1.9	1.4	3.3
	Total	61.6	7.5	69.1	63.5	11.3	71.8	54.3	14.3	68.6	56.3	15.5	71.8
		1-length (302 boards)			3-length (312 boards)			1-length (302 boards)			3-length (312 boards)		
		Better (72.4% of input)	Worse (22.9% of input)	Total	Better (72.8% of input)	Worse (22.4% of input)	Total	Better (63.3% of input)	Worse (31.1% of input)	Total	Better (62.9% of input)	Worse (31.6% of input)	Total
		(% of lumber input)											
No. 2A Common	72	14.4	0.9	15.4	3.4	0.2	3.6	9.4	1.0	10.4	1.6	0.1	1.7
	50, 60	15.1	1.5	16.6	9.2	0.7	9.9	15.5	2.5	18.0	7.2	1.1	8.2
	38, 45	7.2	2.4	9.5	9.6	1.7	11.3	8.4	2.9	11.3	8.8	2.3	11.1
	25,29,33	6.8	3.8	10.6	16.3	3.9	20.2	6.1	5.7	11.8	15.6	6.0	21.7
	15,18	3.7	2.7	6.4	11.4	4.8	16.2	2.9	3.5	6.4	11.0	6.8	17.8
	Primary total	47.2	11.3	58.5	49.9	11.3	61.2	42.3	15.6	57.9	44.2	16.3	60.5
	Salvage	2.5	1.5	4.0	2.3	1.4	3.7	2.0	1.9	3.9	1.8	1.9	3.7
	Total	49.7	12.8	62.5	52.2	12.7	64.9	44.3	17.5	61.8	46.0	18.2	64.2

[a] Crosscut at any point along board length.
[b] Length of shortest piece should be at least 1/4 of full length. Specified minimum = 34 inches that can be overridden.
[c] 1-length = longest possible length between two defects always taken first.
[d] 3-length = use the three lengths that give the greatest yield in primary parts from between two defects.

TABLE 4. - Comparison of yields of primary part lengths from full-length boards (no crosscuts) and the better ends from unrestricted" crosscutting.

Grade	Primary	1-length Full length	1-length Better ends from unrestricted crosscutting lumber	3-length Full length	3-length Better ends from unrestricted crosscutting lumber
	(in.)	(% of lumber input)			
No. 1 Common	72	32.9	29.1	10.1	8.3
	50, 60	13.9	13.4	18.7	15.3
	38, 45	8.4	7.3	10.7	10.6
	25, 29, 33	7.5	5.9	18.3	16.6
	15, 18	4.3	3.2	12.2	10.2
	Total	67.0	58.9	70.0	61.0
No. 2A Common	72	18.7	14.5	4.0	3.4
	50, 60	15.1	15.1	11.5	9.2
	38, 45	9.9	7.2	11.4	9.6
	25, 29, 33	9.7	6.8	19.9	16.3
	15, 18	6.3	3.6	15.6	11.4
	Total	59.7	47.2	62.4	49.9

[a] Crosscut at any point along board length.

lengths. The crosscut procedures caused most of the yield to come from the better pieces. Yield from the worse pieces was concentrated mostly in the shorter lengths.

The values shown in Table 3 reflect the presence or absence of minimum length requirements in the crosscutting procedure. Recall that restricted crosscutting was set up for a minimum length of 34 inches. This has the effect of reducing the amount of material in the better pieces and increasing the amount in the worse pieces relative to unrestricted preprocessing. Not only will this result in less yield from the better pieces, but there will be less yield in the longest lengths.

We believe that higher productivity can come from the gang-ripping system (primary sawing operations) if only the better ends are fed through it. But what of the worse ends? For the unrestricted crosscutting, about 13 percent of the No. 1 Common lumber input was classified as worse pieces as was about 22 percent of the No. 2A Common boards. There is very little traditional salvage (4% or less) in this study. Manufacturers with similar results might want to send the worse pieces to an enlarged salvage operation. This could include more salvage and straight-line ripsaws or the worse pieces could be converted to strips in a separate gang-rip operation. In dual-line roughmills (gang-rip and crosscut systems in parallel), better pieces might be processed on one line and worse pieces on the other. Or perhaps, only the best of the worst would be processed with the rest simply being hogged for fuel. A costbenefit analysis of all options would be desirable.

If a manufacturer wanted to run only the better ends through the main gang ripsaw line, what would be some of the effects of prior unrestricted crosscutting on primary yields? How do primary yields compare with those from fulllength boards? As shown in Table 4, overall yields are less (about 10% for No.1 Common and 12.5% for No. 2A Common). Most of the yield reductions are in the longer lengths. The yields from the worse sections are not counted here. Unrestricted crosscutting before gang-ripping does not appear to increase the amount of short lengths.

DISCUSSION

If all boards were perfect rectangles with defects evenly distributed along the length, no preprocessing of straight boards would be considered because crosscutting would not result in quality and, therefore, yield differences between the ends. However, we have found that when processed with a 1.5* 1.25 floating blade arbor to lengths between 15 and 72 inches, more than half of No. I and No. 2A Common boards have a 10 percent or greater difference in end-to-end yields when the boards are simply crosscut in half. Further, the better ends of these boards are easily recognized by humans. The question becomes: "How can companies capitalize on quality differences within boards?"

To produce the needed amount of rough dimension parts, manufacturers generally size their roughmills to balance employees and equipment with the yields from various lumber grade/mixes. Reasons for not using more lower grade lumber often center around sizing. Using lower grades would require more material, salvaging work, and operators. But, what if the lumber were preprocessed by crosscutting before gang-ripping? This is what we propose.

In our new roughmill, a crosscut saw operator will be stationed in the outflow from the dry kiln with instructions to crosscut out crook and totally defective areas, and to separate the obviously better part of any board from the obviously worse part. Half of the boards from the kiln will pass the crosscut saw without any action being taken. But for the other half, let us consider the effects of unrestricted crosscut-first preprocessing on yields and the potential effects on roughmill design and efficiency.

Up to 5 percent of the crosscut lumber will be waste and will be removed prior to entering the roughmill (material we hogged in this study). This is material that otherwise would interfere with the production process and would have to be removed at the chopsaws or during salvage operations. The presence of this material may well have negative effects on human judgment. Also, preprocessing can reduce waste handling and machine jams due to lumber breakage, and can speed up marking and chopsaw operations that are frequently the bottleneck in a gang-rip-first operation.

Next, we expect at least 10 percent of the No.1 Common and 20 percent of the No. 2A Common to end up in the worse-piece pile. This material is not lost but will be processed to primary lengths in a secondary or salvage operation. The yield patterns will follow the worse yields of Table 3. The material in the better-piece pile (the remaining 70% or so of No. 2A Common and the remaining 80% or so of No. 1 Common) would go directly to the gang ripsaw. The results of this procedure on length distributions in comparison with full-length yields are shown in Table 4.

The yields from the pieces going directly to the gangsaw (better pieces from the unrestricted crosscut procedure) are, of course, less than the total primary yields from full-length processing about 10 percent less for No.1 Common and 12 percent less for No. 2A Common. However, the yield distributions are most interesting. The greatest amount of yield loss is in the shorter lengths, so there is a possibility for improved production efficiency. This is because a 20 percent reduction in No.1 Common input and a 30 percent reduction of No. 2A Common input to the gang ripsaw will result in less overall yield, but more (proportionately) in the more highly valued longer lengths. With No. 2A Common at a relatively low price compared to No.1 Common, preprocessing may well allow more No. 2A Common to be used. Certainly, the main production line will not be able to recognize the grade of lumber from which the pieces came. For mills sized to run shorter lumber, preprocessing and sorting can enhance the ability to match lumber inputs with part size needs.

SUMMARY

A crosscut saw ahead of the gang ripsaw has several potential benefits. Of greatest importance is the ability to remove crook or sidebend. A 5-inch-wide board with 1 inch of crook is only a 4-inch-wide board if the gang ripsaw is used to straighten the board. This would be a minimum yield loss of 20 percent from a clear board. The benefits of removing crook are discussed in detail in earlier work.[2,3] Prior to gang-ripping, the crosscut saw can be used to remove unusable portions of lower grade boards (about 5%).

If a manufacturer is concerned that the lower grades of lumber do not contain enough yield to fill production needs, separating the better sections from the worse and feeding only the better sections through the main roughmill line might allow more of the lower grades to be used. About half of all boards from the kiln will have end-to-end yield differences of 10 percent or more. These boards are easily recognized. At least 80 percent of the preprocessed lumber will be classified as better.

The worse ends, in whole or in part, could be processed in a separate salvage operation. Or, the longer pieces might be sent through the gang ripsaw at a later time. It could be decided that only the best of the worst will be processed at all. A cost-benefit analysis might show that the worst of the worst should be hogged. A crosscut saw ahead of the gang ripsaw increases management options for processing lower grades of lumber.